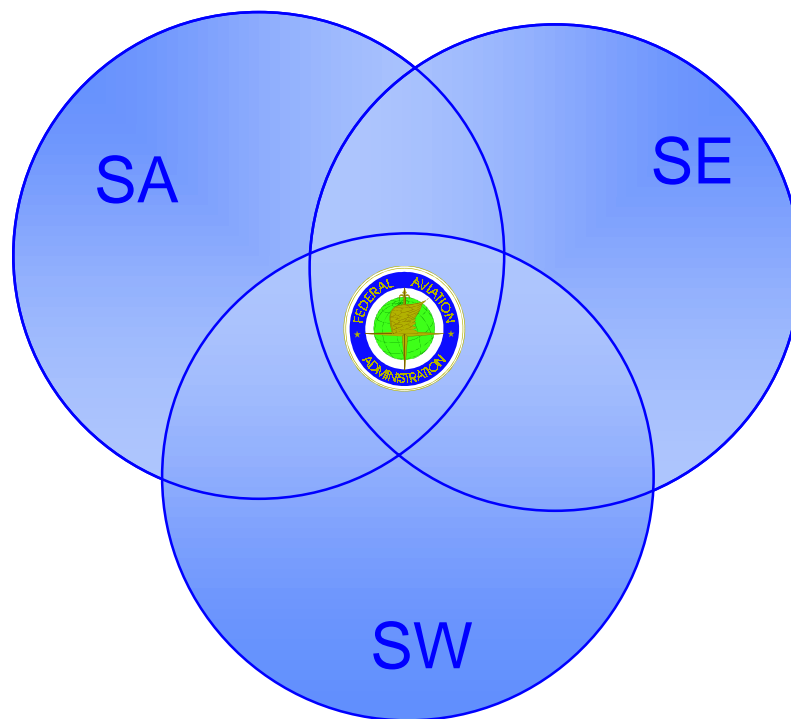# The Human Factors Engineering Addendum

to the

Federal Aviation Administration Integrated Capability Maturity Model^{sm} (FAA-iCMM$^®$) Version 1.0

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The Human Factors Engineering Addendum
to the FAA-iCMM® v 1.0

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Preface

Introduction

This Human Factors Engineering Addendum to the Federal Aviation Administration integrated Capability Maturity Model (FAA-iCMM) v1.0 was developed to provide guidance to the FAA in improving its human factors engineering (HFE) practice. Since the FAA has adopted the FAA-iCMM as its reference model for improving acquisition, management, and engineering practice, including HFE in the FAA-iCMM offers a potential mechanism for integrating HFE improvement into the FAA's ongoing process improvement initiative in a consistent way.

It is a principle of Capability Maturity Models (CMMs) that they contain best practices that have been widely demonstrated to be effective in actual use. Since there is no "HFE-CMM" containing such practices, the practices in this addendum have been drawn from various sources *(see References).* They will be validated through application on pilot projects in the FAA over the coming year. After trial use, and midcourse adjustment as required, the HFE improvement guidance material will be reviewed again and considered for inclusion in the FAA-iCMM *(see Validation).*

This addendum was developed by FAA HFE subject matter experts with guidance from CMM authors and experts. Subject matter experts in the FAA-iCMM disciplines, potential users of this HFE addendum from FAA product teams, and external HFE and CMM experts participated in the review process *(see Participants).*

During this period of trial use, additional comments may be submitted to the FAA-iCMM Project Leader *(see Change Request Form).*

Structure of the addendum

The HFE addendum is structured in two parts as follows:

1. HFE Process Area
A Draft Human Factors Engineering (HFE) Process Area, PA 24, is the first part of the addendum. This process area follows the standard process area template of the FAA-iCMM and
- Describes best practice in conducting HFE and integrating HFE into a system acquisition
- Provides more specialized guidance regarding HFE aspects of several of the process areas already in the FAA-CMM

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2. HFE Input for FAA-iCMM Process Areas
The second part of the addendum provides draft HFE augmentations to the 23 process areas of the FAA-iCMM. For each FAA-iCMM PA, the following are provided:
- The name of the FAA-iCMM process area
- Human Factors Engineering Considerations: This section suggests some areas to be changed or emphasized in the process area in order to facilitate the application of HFE
- Human Factors Engineering Relationships: This section provides references to the HFE Process Area, PA 24, where more detailed guidance is provided.
- Other changes: This section provides other suggested changes to the process area to ensure HFE is included, as applicable

Validation

The HFE/FAA-iCMM integration effort was challenged with several issues regarding how to structure HFE practices for inclusion in the model. These issues, which are outlined below, will be explored during the trial implementation and validation project.

1. Separate Emphasis vs. Integration
A major challenge was to find a way to include HFE in the FAA-iCMM that would clearly emphasize specific essential HFE practice, yet also ensure that HFE is addressed as an integral part of the acquisition life cycle process. Would it be sufficient and effective to enhance existing process areas with more detailed HFE guidance, or should a separate process area be developed to specifically address HFE practice?   Should both approaches be followed? Are both necessary?

2. Ease of Use
A related issue was to package HFE practice so as to be useful to all potential users. A general HFE advisor might want to find everything related to HFE in one place in the model (a separate process area) whereas product team practitioners might prefer to have all guidance about a process area, including all specialty considerations, packaged around that process area.   Which approach provides more clarity and more effective guidance? Should both be provided?

3. Measurement and Appraisal
Goals and practices are the normative aspects of a CMM that are used during appraisals. Other parts are informative. Since CMMs are typically validated through pilot appraisals, could enough HFE emphasis be placed in existing process areas to be able to measure HFE improvement via appraisal? Do existing goals and practices of the current process areas adequately capture HFE? Are additions required? Would a separate process area provide more effective guidance?

4. Efficiency in process improvement
Efficiency in implementing improved processes is another important consideration. What structuring approach would be most easily and efficiently implemented, trained, and appraised?

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5. Other specialty fields

What about other specialty engineering fields that are also critical to the FAA such as safety , security, reliability and maintainability, etc? Will we also address these specialties in the FAA-iCMM? How? Would a new dimension of technical generic practices be an appropriate way to capture technical practices that apply to many process areas?

Rather that theorizing about such issues, we have decided to experiment with one critical specialty field, HFE, and see what type of process improvement guidance proves to be effective and efficient in practice. The initial structuring decision for this addendum, as described above, offers one way of structuring a specialty engineering field for inclusion in an integrated CMM. This approach will be piloted and we expect to learn from this experiment how best to evolve a CMM to include specialty fields that are considered essential aspects of life cycle management of service delivery.

A plan for trial use of the material in this addendum has been developed. It addresses the HFE trial implementation project purpose, goals and expected benefits, approach, specific pilot programs, resource requirements, deliverables, major tasks and milestones, training requirements, validation measures and procedures, review procedures, schedule, risks, success factors, roles and responsibilities, etc. The project will be monitored by the FAA-iCMM Project Team and the FAA integrated Process Group (iPG) over the coming year.

Participants

We are gratified by the number of people who participated in the preparation of this addendum.

Sponsors: Mark Rodgers, Acting Chief Scientist for Human Factors, AAR
Art Pyster, Acting Deputy Chief Information Officer and Chief Scientist for
     Software Engineering, AIO
     *(also Maureen Pettitt, previous Chief Scientist for Human Factors, no longer
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References

The following references were used in the development of this HFE Addendum:

Booher, H. R. (Ed.). (1990). MANPRINT: An Approach to Systems Integration. New York: Van Nostrand Reinhold.

Cardosi, K. M., & Murphy, E. D. (Eds.). (1996). Human Factors in the Design and Evaluation of ATC Systems: A Handbook for FAA User Teams. Washington, DC: USDOT/FAA.

DOD-HDBK-763, Human Engineering Procedures Guide (February 1987)

FAA, Human Factors Job Aid (September 1997)

FAA, Human Factors Design Guide (January 1996)

ISO/TC 159/SC 4 N, Ergonomics – Ergonomics of human-system interaction – Human-centred lifecycle processes descriptions (1998-10-15)

MIL-HDBK-46855, Human Engineering Guidelines for Military Systems, Equipment, and Facilities (January 1996)

MIL-HDBK-759, Human Engineering Design Guidelines (February 1997)

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MIL-STD-1472, DOD Design Criteria Standard: Human Engineering (October 1996)

National Research Council (1997). Flight to the Future: Human Factors in Air Traffic Control. Washington, DC: National Academy Press.

PA 24: Human Factors Engineering

Process Area Summary

Purpose
The purpose of Human Factors Engineering is to ensure that systems acquired are operationally safe, effective, and suitable from a perspective of human performance.

Major points addressed
The Human Factors Engineering process area involves a multidisciplinary effort to generate and compile information about human capabilities and limitations and apply that information to hardware, software, facilities, procedures, jobs, environments, training, staffing, and personnel management, to produce systems that are operationally safe, effective, and suitable. The human factors engineering process involves a systematic approach to the identification and resolution of issues related to human-system performance and human resources.

Human factors engineering is applied in the context of the total system concept in which the operator, maintainer, system, and operating environment are all integral components of the whole system.

Human factors engineering is initiated during mission analysis activities and fully integrated with the investment, development, and systems engineering efforts throughout the acquisition lifecycle.

Goals
1. Human factors engineering is addressed as an integral part of the system acquisition lifecycle. *(BP 24.01)*
2. Human factors information requirements and human-system performance needs are identified, analyzed, and documented. *(BP 24.02)*
3. Human-system performance is verified to have achieved system acquisition objectives for operational safety, suitability, and effectiveness. *(BP 24.03)*

Notes
When acquiring a system, experience has shown that acquisition programs tend to focus on the hardware and software and may ignore the impact on, and of, the people who operate and maintain the system. End users may have different aptitudes, abilities, cultural backgrounds, and training and may operate the system and respond to the system under various operating conditions, organizational structures, procedures, equipment configurations, and work scenarios. And, it is the composite of these elements (including the human response) that determines the performance, safety, and efficiency of the system.

Because there is a dynamic interaction among the major elements of a system (e.g., equipment/software design, environment, staffing and training, and procedures),

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investment and systems engineering trade-off decisions that consider human factors are required to assure that system operational performance objectives are met.

When human factors is applied at the onset of the acquisition lifecycle, it enhances the probability of meeting performance, safety, and productivity requirements; decreases lifecycle staffing and training costs; and becomes well-integrated into the program's strategy, planning, cost and schedule baselines, and technical trade-offs. Although HFE may be applied in different ways under different acquisition strategies, these benefits are applicable to commercial-off-the-shelf (COTS) and non-developmental items (NDI) as well as to developmental programs.

The term *user* refers to all people who use the system (i.e., including the personnel that operate equipment and those expected to maintain and support the system throughout its lifecycle).

 Achieving the human-system performance objectives related to safety, suitability, and effectiveness can be considered to be synonymous with meeting usability goals, since high standards of usability must be realized in order for systems to meet high standards of safety, suitability, and effectiveness.

The term "Human Factors Engineering" is intended to include the full scope of human response and human-system performance concerns inclusive of such terms as human-computer interaction (HCI), man-machine interface (MMI), computer-human interface (CHI), Human-System Interface (HSI), and other similar terms.

Relationships between this PA and other PAs
Human factors engineering concepts are applied to the activities and products of other process areas. Human factors engineering also uses the practices, methods, and work products of the other process areas to satisfy human factors engineering process requirements. HFE provides guidance for carrying out other PAs especially when HFE is integral to the product or service acquired. These relationships should be emphasized in the process areas associated with: Needs (PA 01), Requirements (PA 02), Architecture (3), Alternatives (PA 04), Outsourcing (PA 05), Software Development and Maintenance (PA 06), Integration (PA 07), System Test and Evaluation (PA 08), Project Management (PA 11), Contract Management (PA 12), Risk Management (PA 13), and Coordination (PA 14).

Base Practices list
The following list contains the human factors engineering base practices that are essential elements of good systems acquisition:

BP 24.01 **Integrate Human Factors Engineering in All Phases of Acquisition:** Develop the strategy, approach, and procedures for the integration of human factors engineering in system acquisition and engineering activities.

BP 24.02 **Conduct Analyses, Studies, or Research to Generate Human Performance Information:** Conduct analyses, studies, or research to generate human

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performance information that mitigates the risks associated with human factors engineering acquisition issues.

BP 24.03 **Ensure that Human-System Performance Objectives are Met**: Produce evidence of the degree to which the total system meets performance objectives and can be operated and maintained by members of the target population in an operational environment.

BP 24.01   Integrate Human Factors Engineering in All Phases of Acquisition

Develop and carry out the strategy, approach, and procedures for the integration of human factors engineering in system acquisition and engineering activities.

Description
In conjunction with the system technical and operational requirements and acquisition/development strategy, define the concepts, mechanisms, responsibilities, and procedures for integrating human factors engineering in the acquisition. Establish the human factors engineering strategy and approach for applying human factors engineering to the system being acquired by focusing on the human performance produced when the system is operated and maintained in an operational environment by members of the intended target population. The approach to human factors engineering should include identifying and translating operational requirements into human engineering design, development, and implementation concepts and requirements, and identifying the human performance boundaries, risks, trade-offs, and opportunities of the systems engineering options and alternatives. These activities apply the results of research and other sources of human factors information related to design enhancements, safety features, automation impacts, human-system performance trade-offs, ease of use, and workload. To effectively integrate human resource and performance considerations for the system being acquired (as well as for other associated or neighboring systems), the human factors engineering effort is focused on:
- Improved human interfaces of the system
- Effectiveness of human performance during system operation, maintenance, and support
- Demands upon personnel resources, skills, training, and costs

Typical Work Products
- Relevant demographics and performance parameters of the target audience
- Review of predecessor system assessments to identify human performance issues
- Initial risks, enhancements opportunities, and issues related to human-system performance
- Activities to be conducted in support of obtaining the required information about human performance
- Documented strategy for the application of human factors engineering to products and services
- User feedback mechanisms
- HFE strategy, approach, and prcedures
- Human factors engineering plans embedded in system engineering plans
- Inputs to key acquisition, solicitation, and system engineering documentation

Notes
Establishing the human factors engineering strategy and approach for a given system acquisition requires focusing on the tasks the end users will perform on the system and on the program activities that allow early identification and resolution of human performance

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issues. The origins of the human factors engineering integration approach occur early in the acquisition lifecycle (as early as during mission analysis), and are refined during each subsequent acquisition phase, as required.

Where user teams or operator and maintainer representatives participate in providing the design and development team an operational viewpoint, human factors engineering conducts the appropriate user activities to ensure the data collected represents performance data and not just individual preferences.

The human factors engineering inputs to the acquisition documentation define: a) the human performance requirements, capabilities, thresholds, and criteria the system is to meet; b) any impact on the acquisition strategy to be taken; c) the performance and resource trade-offs to be encountered; d) and the specific tasks and activities that must be performed during system design, development, and implementation. Human factors engineering inputs are formulated to improve or resolve issues related to, at a minimum, the following essential elements for all users:
- Staffing (and organizational) constraints
- System operator and maintainer (user) skills
- Training performance, time available, and cost limitations for formal, informal, and on-the-job skill development
- Acceptable levels of human and system performance when operated and maintained by members of the target population

Identification of human resource and human performance considerations facilitates the development of system concepts for hardware and software, functional allocation, operations and training, and organizational structures. An iterative approach is advocated for assessing the trade-offs of various human performance and human resource alternatives with other system concepts (e.g., for requirements, design, and implementation). This practice applies equally to developmental and to non-developmental items (NDI) or commercial-off-the-shelf (COTS) acquisitions.

To reduce potential data redundancies, emphasis should be placed on coordination between the human factors engineering and integrated logistics support (ILS) for information requirements planning, data collection, and information sharing, especially in the areas of maintenance staffing, training, training support, and personnel skills.

Human factors engineering contributes to system engineering design and development decisions. Example activities in the human factors engineering are:
- Identify human factors engineering tasks and human performance unknowns or issues for resolution or mitigation
- Review system operation and maintenance concepts for human performance implications
- Develop a profile of the people (e.g. aptitudes, skills, anthropometric data, population distribution, capabilities, training history) who operate, maintain, and support the system
- Identify operator and maintainer tasks for explicit and implied human-system interfaces
- Devise a human factors engineering strategy

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- Allocate human factors engineering tasks and activities for integration into the overall program plan
- Tailor and refine the human factors approach and requirements
- Document results and lessons learned for their application to other programs
- Prepare human performance portions of operations and maintenance mission profiles and mission scenarios
- Contribute to the preparation of human performance specifications for the system
- Perform functional analyses of flow block diagrams for human-system operations and define operational and support equipment and facilities requirements
- Study detailed functions, environment and technical design requirements to allocate tasks to personnel, equipment, software, or some combination to achieve system engineering goals
- Prepare and analyze operations and maintenance workload and task data to influence equipment and procedure design, and to determine personnel requirements
- Identify training implications of alternative designs
- Conduct trade studies of human response and performance with system design alternatives
- Embed human-system performance considerations in system specifications and translate the human performance design and integration activities to the contractor as clear, unambiguous requirements in a contractually binding way
- Prepare the human factors engineering portion of proposal evaluation criteria and the source selection plan
- Contribute human performance information and criteria to the source selection team process

BP 24.02   Conduct Analyses, Studies, or Research to Generate Human Performance Information

Conduct analyses, studies, or research to generate human response and human performance information that mitigates the risks associated with human factors engineering issues.

Description
A broad range of information gathering activities regarding the implications of human factors is conducted to support system acquisitions. These activities involve acquiring the information necessary to capitalize upon the understanding of the human capabilities and limitations that affect human-system performance. Human factors engineering research and analysis activities are employed to identify and resolve risks and to assess costs, benefits, performance levels, and trade-offs. Areas in which human factors analyses, studies, and research investigate include:

- Computer-human interface (CHI)

- Controls, displays, and alerts

- Procedures, incremental changes to systems, system upgrades, and system component integration

- Workforce productivity; accuracy levels, error rates and their consequences; workload; usability; and task performance

- Training for new automation operation and maintenance

- Equipment, workspace, and workplace design

- Manpower and staffing; unique skills, abilities, characteristics, and tools; communications and teamwork; job and organizational design

- Human performance aspects of safety, health, and environmental considerations

Typical Work Products
- Analysis, study, and research requirements and initiatives
- Research and study proposals, plans, and descriptions
- Technical reports and analyses providing research and study results
- Human performance and human factors engineering guidance, conventions, and technical direction for integration in system design and development alternatives
- User human performance data and information from post-fielding human factors engineering feedback mechanisms
- Human factors engineering functional, task, and operational performance analysis results (e.g. functional requirements for the user, minimum performance criteria) to support system design and engineering activities

Notes
Human factors engineering analyses, studies, and research conducted early in the program identify design considerations as well as human-system performance risks and

unknowns that require greater exploration during later phases of the system acquisition. These studies also assess the level of risk and related consequences to assist in estimating resource requirements for the follow-on analyses. Example activities include the following:

- Human-in-the-loop simulations
- Task and task sequence analyses (including cognitive task analyses)
- Use and usability studies
- Operation and maintenance timeline analyses for human-system reaction times
- Readability analyses
- System comparative studies (such as predecessor system early comparison analyses, ECA)
- Human performance trade-off analyses
- Skill decay and training performance studies
- Post fielding assessments of human performance
- User feedback surveys

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BP 24.03 Ensure that Human-System Performance Objectives are Met

Produce evidence of the degree to which the total system meets performance objectives and can be operated and maintained by members of the target population in an operational environment.

Description
Human performance testing is performed to assist in the assessment of the operational effectiveness and suitability of the products to meet system requirements. Human factors engineering planning for test and evaluation (T&E) activities is initiated early in the acquisition lifecycle. Specific human factors engineering-related T&E tasks and activities are subsequently identified, and the conduct of the human factors engineering T&E is then integrated with the system T&E program. Post deployment assessments that include human performance parameters are conducted to assist in lifecycle planning, continuous improvement, or other programs.

Typical Work Products
- Human factors engineering test planning documentation for inclusion in the system test and evaluation planning
- Information required for resolution by human factors studies, analyses, or research
- Operator and maintainer task lists (especially critical tasks) to meet system performance goals
- Human performance measures of effectiveness and measures of performance
- Human performance data requirements and data collection plans
- Data collection methods, surveys, questionnaires, analyses, and evaluation schemes
- Human factors engineering reviews and demonstrations
- Resource requirements for human performance tests including equipment, software, data analysis skills, data collection personnel, computer time, personnel training requirements

Notes
 Human factors engineering test and evaluation is conducted to:
- Ensure fulfillment of the applicable human performance requirements
- Demonstrate conformance of system, equipment, and facility design to human engineering design criteria
- Confirm compliance with system performance requirements where human performance is a system performance determinant
- Secure quantitative measures of system performance which are a function of the human interaction with equipment
- Determine whether undesirable design or procedural features have been introduced

Key principles for addressing human factors engineering requirements in system testing are:
- Coordinate human factors test planning early in the acquisition program
- Measure human performance of critical tasks during testing in terms of time, accuracy, and operational performance

- Emphasize the separation of measuring human performance from measuring system performance
- Leverage human factors data collection by integrating efforts with system performance data collection
- Make recommendations for human factors design and implementation changes and human performance improvements

Human engineering components of test and evaluation include:
- Performance measures of task or mission
- Critical tasks (including cognitive tasks)
- Representative samples of non-critical, scheduled and unscheduled maintenance tasks
- Personnel who are representative of the range of the intended user populations
- Proposed job aids, new equipment training programs, training equipment, and special support equipment
- Collection of task performance data in actual operational environments
- Identification of discrepancies between required and obtained task performance
- Criteria and thresholds for acceptable performance

Unfavorable outcomes occurring during test and evaluation are subjected to a human factors engineering review to differentiate between failures of the equipment alone, failures resulting from human-system incompatibilities and failures due to human error. Human-system incompatibilities and human errors occurring in the performance of critical tasks are analyzed to determine the reason for their occurrence and to propose corrective action(s).

Example activities include:
- Conduct Front-end Analyses to identify critical operational issues, resource limitations and constraints, critical tasks, and operator and maintainer performance levels as well as system performance thresholds that are to be incorporated into the testing program
- Develop human factors testing requirements using human performance measures of effectiveness and measures of performance for system operational effectiveness and operational suitability
- Contribute to system critiques during design and program reviews, technical demonstrations, and operational tests
- Conduct human performance testing to estimate or verify operational effectiveness and suitability and to provide information about human performance as an integral part of system performance
- Apply results of human performance testing to system development decisions

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Human Factors Engineering Input for Existing FAA-iCMM Process Areas

Introduction

Rather than change the FAA-iCMM Process Areas (PAs) themselves for the purposes of this addendum, draft human factors engineering (HFE) augmentations are provided for each PA, listing HFE considerations for that PA. These augmentations are to be used in conjunction with the FAA-iCMM PAs during the period of trial HFE validation and use.

Each PA augmentation includes the following information:

Human factors engineering considerations. This section suggests some areas to be changed or emphasized in the FAA-iCMM PA in order to facilitate the application of HFE.

Human factors engineering relationships. This section provides references to further guidance found in Human Factors Engineering PA 24.

Other proposed human factors engineering changes. This section provides other suggested changes to the process area to ensure HFE is included.

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PA 01: Needs

Human factors engineering considerations	In BP 01.01 Elicit Needs, needs should be elicited to include measures of suitability. Examples of techniques to elicit needs should include results of HFE analyses, studies, or research.
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition BP 24.02 Conduct Analyses, Studies, or Research to Generate Human Performance Information
Other proposed human factors engineering changes	In BP 01.04 Obtain Customer Agreement • under description, change "operations concept" to "concepts of operation and maintenance".

PA 02: Requirements

Human factors engineering considerations	Especially early in the acquisition lifecycle, there is a tendency to under-estimate the importance of the detailed operational concepts and requirements that impact on or result from human performance and system acceptability considerations. In order to achieve the desired user-centered design and development goals that will contribute to system effectiveness and suitability, appropriate emphasis must be placed on human resource and human-system performance requirements.

In BP 02.03 Derive and Partition Requirements, requirements should be derived and partitioned that are determined to be essential to suitability as well as system effectiveness. |
| *Human factors engineering relationships* | BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition
BP 24.02 Conduct Analyses, Studies, or Research to Generate Human Performance Information |
| *Other proposed human factors engineering changes* | In Process Area Summary,
• under "Major points addressed", in the first sentence, change "concept of operations" to "concepts of operations and maintenance".
• under "Relationships between this PA and other PAs", add a sentence to the end of the paragraph that reads: "Use of Human Factors Engineering (PA 24) practices help ensure that human response and human-system performance requirements are adequately addressed."

In BP 02.01 Develop Detailed Operational Concept,
• under "Description", revise the fourth sentence which ends "for each system element" so as to end as "for each system element (to include the human element)".
• under "Description", add to the end of the last sentence "or emergency operations".

In BP 02.02, Identify Key Requirements,
• under "Typical Work Products", add a bullet "human resource (e.g. staffing, training) constraints".
• under "Typical Work Products", add a bullet "human performance objectives or limitations". |

PA 02: Requirements, continued

Other proposed human factors engineering changes, continued

In BP 02.03 Derive and Partition Requirements
- change the base practice statement to include the words "and suitability" after "effectiveness".
- under the third paragraph concerning "examples of requirements related to production and operations", in the last bullet substitute the words "operators/users and maintainers" for "operators/users".

In BP 02.04 Develop Interface Requirements
- under "Typical Work Products", add a bullet "computer-human interface (CHI) requirements".

PA 03: Architecture

Human factors engineering considerations	To be determined.
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition
Other proposed human factors engineering changes	None.

PA 04: Alternatives

Human factors engineering considerations	To be determined.
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition BP 24.02 Conduct Analyses, Studies, or Research to Generate Human Performance Information BP 24.03 Ensure that Human-System Performance Objectives are Met
Other proposed human factors engineering changes	In Process Area Summary • under Major points addressed, in the last line of the last sentence, add "or operational" between the words "technical" and "decision" In BP 04.01 Establish Evaluation Criteria • under "Notes", in the second line, add "system suitability, usability" between "effectiveness" and "producibility." In BP 04.02 Define Analysis Approach • under "Notes", modify the second bullet to add "(including human-in-the-loop simulation)"

PA 05: Outsourcing

Human factors engineering considerations	As a component of the factors affecting solicitation, human factors engineering criteria (quantitative and qualitative) must be appropriately visible and given sufficient weight, consistent with the nature of the program including the degree of human involvement, human-system performance risks, human resource intensity, consequence of error, and the like.
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition BP 24.02 Conduct Analyses, Studies, or Research to Generate Human Performance Information
Other proposed human factors engineering changes	In BP 05.03 Prepare for the Solicitation • under "Notes", add the following: "As a component of the factors affecting solicitation, human factors engineering criteria (quantitative and qualitative) must be appropriately visible and given sufficient weight, consistent with the nature of the program including the degree of human involvement, human-system performance risks, human resource intensity, consequence of error, and the like."

PA 06: Software Development and Maintenance

Human factors engineering considerations	Base practices BP 06.02 Analyze Allocated Requirements, BP 06.03 Design Software, and BP 06.07 Develop Documentation have direct impact on the humans (system operators and maintainers) that must use the developed software. In performing these practices, the Human Factors Engineering Process Area (PA24) should be considered and applied as appropriate.
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition BP 24.03 Ensure that Human-System Performance Objectives are Met
Other proposed human factors engineering changes	In Process Area Summary, • under Relationships between this PA and other PAs, add a new relationship as follows, "Base practices BP 06.02, 06.03, and 06.07 have direct impact on the humans (system operators and maintainers) that must use the developed software. In performing these practices, the Human Factors Engineering Process Area (PA24) should be considered and applied as appropriate." In BP 06.02 Analyze Allocated Requirements • to the list of examples of individuals who review the software requirements document add, "the human factors engineering specialist." In BP 06.03 Design Software • to the end of the second subparagraph under "Description" add, "Ensure that the software detail design supports human performance in the tasks and activities that the operators and maintainers must perform."

PA 07: Integration

Human factors engineering considerations	To be determined.
Human factors engineering relationships	BP 24.03 Ensure that Human-System Performance Objectives are Met
Other proposed human factors engineering changes	In BP 07.01 Define Interfaces • between the first and second sentence to "Notes" add, "Examples of components of human interface specifications include Informational (e.g., displays, content, and media), Cooperational (e.g., individual and team communication), Environmental (e.g., workspace, physical, and psychological), and others."

PA 08: System Test and Evaluation

Human factors engineering considerations	In assessing potential operational performance issues, emphasis is to be placed upon the system performance when operated or maintained by members of the target population in the intended environment so as to contribute to the identification (and resolution) of human factors causal information.

Human factors engineering relationships	BP 24.03 Ensure that Human-System Performance Objectives are Met

Other proposed human factors engineering changes

In Process Area Summary:
- to the end of the first sentence under Relationship Between this PA and Other PAs add, "and Human Factors Engineering (PA24)."
- under "Notes" add the sentence: "In assessing potential operational performance issues, emphasis is to be placed upon the system performance when operated or maintained by members of the target population in the intended environment so as to contribute to the identification (and resolution) of human factors causal information."

In BP 08.01 Develop Evaluation Strategy and Requirements
- add a new bullet under "Notes" as follows, "identify the human performance requirements to be evaluated."

In BP 08.02 Define Evaluation Procedures,
- under "Description", 2nd subparagraph, 1st line: Change "user/operator" to "includes the customer/user and maintainer of the system."
- under "Typical Work Products", add a bullet: "data collection and analysis plans (including human performance data)"

In BP 08.03 Incorporate Evaluation Requirements into the Solicitation and Contract
- add a new bullet under "Description" as follows, "requirements to ensure that the contractor evaluates human performance as a component of the product's evaluation activities."

In BP 08.05 perform Planned Evaluations
- in last sentence of "Description", delete "periodically" and add "its usability and" before "the satisfaction of operational requirements."

PA 09: Transition

Human factors engineering considerations	To be determined.
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition
Other proposed human factors engineering changes	In BP 09.02 Develop and Follow a Transition to Support Strategy • add a new sentence under "Notes" as follows, "Creating and following a systemic approach and strategy for support of all subsystems and related items assists in responding to the transition requirements while minimizing the changes of, or impact on, personnel resources, training, and support infrastructure."

PA 10: Product Evolution

Human factors engineering considerations	To be determined.
Human factors engineering relationships	BP 24.02 Conduct Analyses, Studies, or Research to Generate Human Performance Information
Other proposed human factors engineering changes	No changes proposed for this PA.

PA 11: Project Management

Human factors engineering considerations	To be determined.
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition
Other proposed human factors engineering changes	In Process Area Summary • in "Relationships between this PA and other PAs", add "and PA 24" to last sentence so as to read "and will coordinate and work with Support Processes (PAs 15-19 and PA 24) throughout the project's life cycle." In BP 11.01 Identify the Activities • in "Description", add "human factors engineering issues" to the second sentence (sixth line) so as to read "… risk management including identifying cost and schedule risks, available and projected technologies, human factors engineering issues, and system testing." • in "Typical Work Products" add a bullet (in appropriate order) "Concepts of operation and maintenance". In BP 11.05,Establish and Maintain Plans • in "Notes", under the paragraph on "Examples of technical parameters…", add a bullet "time and accuracy of task performance". In BP 11.06 Establish Commitment • in "Notes", under the paragraph on "Affected groups and individuals…", add a bullet (in appropriate order) "human factors engineering specialists".

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PA 12: Contract Management

Human factors engineering considerations	To be determined.
Human factors engineering relationships	BP 24.03 Ensure that Human-System Performance Objectives are Met
Other proposed human factors engineering changes	In BP 12.01 Review and Use Planning Documents • in "Typical Work Products", add a bullet (in appropriate order) "human factors engineering planning"

PA 13: Risk Management

Human factors engineering considerations	To address the risk that the system will not be acceptable to the user, identify specific points in the development cycle where operators and maintainers provide inputs using rapid prototyping, simulations, and prototype systems.
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition BP 24.03 Ensure that Human-System Performance Objectives are Met
Other proposed human factors engineering changes	In Process Area Summary • in "Relationships between this PA and other PAs," add "Human Factors Engineering (PA 24)" to list of relationships. In BP 13.02 Identify Risks • in "Notes" second paragraph under the first bullet, add "Human factors engineering" to the serial list of categories of risk. BP 13.03 Assess Risks • in "Description", add to end of third sentence "…or design of the user/system interface." • under "Notes" second paragraph on "Examples of activities to mitigate risks", add the following bullets: • "To address the risk that the system will not be acceptable to the user, identify specific points in the development cycle where operators and maintainers provide inputs using rapid prototyping, simulations, and prototype systems." • "To address human performance risk, develop a plan to establish HITL performance projections during preliminary design and assess HITL performance during development." In BP 13.04 Review and Validate Risk Assessment • under "Notes", modify first bullet as follows: "Hold a meeting of all stakeholders of the project including representative system operators and maintainers to present the risk assessment…."

PA 14: Coordination

Human factors engineering considerations	To be determined.
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition
Other proposed human factors engineering changes	No changes proposed for this PA.

PA 15: Quality Assurance and Management

Human factors engineering considerations	To be determined.
Human factors engineering relationships	To be determined.
Other proposed human factors engineering changes	In Process Area Summary, • under relationships between PAs, add "Human Factors Engineering (PA 24)" to second sentence. In BP 15.02 Evaluate Product and Process • under "Notes" add a bullet to the Examples of tools to use in measuring the process to include: "Human-in-the-loop simulation and assessments for human response and consequences" In BP 15.04 Record and Report Results • under "Description", add to end of the first sentence in the second paragraph "...including the user". In BP 15.05 Analyze Quality • under "Typical Work Products," modify the second bullet to read "failure analysis including human error"

PA 16: Configuration Management

Human factors engineering considerations	To be determined.
Human factors engineering relationships	To be determined.
Other proposed human factors engineering changes	In BP 16.02 Identify Configuration Units/Items • under "Typical Work Products", add a bullet under the "identified configuration units/items such as" to read "user interface requirements including computer-human interface (CHI)" In BP 16.06 Conduct Configuration Audits • under "Notes", add: "The specified performance levels are to include human-in-the-loop, where applicable."

PA 17: Peer Review

Human factors engineering considerations	To be determined.
Human factors engineering relationships	To be determined.
Other proposed human factors engineering changes	No changes are proposed for this PA.

PA 18: Measurement

Human factors engineering considerations	To be determined
Human factors engineering relationships	To be determined
Other proposed human factors engineering changes	No changes are proposed for this PA.

PA 19: Prevention

Human factors engineering considerations	To be determined
Human factors engineering relationships	To be determined
Other proposed human factors engineering changes	No changes are proposed for this PA.

PA 20: Organization Process Definition

Human factors engineering considerations	To be determined
Human factors engineering relationships	BP 24.01 Integrate Human Factors Engineering in All Phases of Acquisition BP 24.02 Conduct Analyses, Studies, or Research to Generate Human Performance Information BP 24.03 Ensure that Human-System Performance Objectives are Met
Other proposed human factors engineering changes	No changes are proposed for this PA.

PA 21: Organization Process Improvement

Human factors engineering considerations	To be determined
Human factors engineering relationships	To be determined
Other proposed human factors engineering changes	No changes are proposed for this PA.

PA 22: Training

Human factors engineering considerations	To be determined
Human factors engineering relationships	To be determined
Other proposed human factors engineering changes	No changes are proposed for this PA.

PA 23: Innovation

Human factors engineering considerations	To be determined
Human factors engineering relationships	To be determined
Other proposed human factors engineering changes	No changes are proposed for this PA.

Glossary

Other proposed human factors engineering changes	Change the term "End User" to include the operator and maintainer.

Change Request Form

SECTION I: TO BE COMPLETED BY REVIEWER			
Name/Organization:		Phone:	Email:

Problem Title:	❑ MODEL
	  ❑ Architecture
	  ❑ PAs
	  ❑ Terminology
	  ❑ _____
		❑ APPLICATION
		  ❑ Appraisal Method
		  ❑ Pilots
		  ❑ Assurance
		  ❑ _____
			❑ PROJECT
			  ❑ Sponsorship
			  ❑ Participation
			  ❑ Schedule
			  ❑
			    _____
			    _____

Description of problem (use back if needed):

Impact if the problem is not resolved:

Possible solutions:

SECTION II: TO BE COMPLETED BY FAA-iCMM Project

❑ Accepted   ❑ Rejected   Priority: ❑ High ❑ Medium ❑ Low
Rationale:

Action Required:

Disposition:

Assigned to:
❑ Sponsorship & Adoption   ❑ Planning & Infrastructure   ❑ Model WG   ❑ Appraisal WG ❑ _____

Due Date: